

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In the Patent Application of

Kurt Ulmer et al.

Application No. 10/674,053

Filed: September 29, 2003

For: Fuel Cell Modulation and Temperature
Control

Group Art Unit: 1795

Examiner: LEWIS, Ben

DECLARATION UNDER 37 CFR §1.132

Mail Stop Appeal Brief - Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

I, an undersigned inventor of the above-identified patent application, hereby declare the following.

At the time the invention of the above-identified patent application was made, I was an employee of Hewlett-Packard Co. working in the design of fuel cell systems. As such a professional, I am qualified to comment on the level of ordinary skill in this art.

U.S. Patent Application Publication No. 2003/0008184 to Ballantine

U.S. Patent Application Publication No. 2003/0008184 to Ballantine ("Ballantine") describes a "cogeneration fuel cell system" that "is operated among various modes to **balance heat and power demand signals**. In general, a fuel cell system is coupled to a power sink and a heat sink, and a controller is adapted to respond to data signals from the power sink and the heat sink." (Ballantine, Abstract) (emphasis added). Ballantine teaches "generating a heat demand signal when the thermal parameter of the heat sink is below a predetermined level; and . . . selectively connecting at least two fuel cells in the fuel cell stack *in parallel in response to the heat demand signal*. (Ballantine, para. [0015]) (emphasis added). Similar language is contained in paragraph [0129] of Ballantine as well.

Further, Ballantine teach connecting fuel cells in parallel in response to a heat demand signal (e.g. in order to increase heat within a system) throughout the Ballantine reference. For example, Ballantine teaches that

[i]n a first operating mode, the sections of cells are connected in series, and *in a second operating mode, at least two sections of cells are operated in parallel*. In general, the first and second operating modes will provide different operating efficiencies in terms of the amount of heat produced per unit power. For example, *the second operating mode may produce more heat*. (Ballantine, para. [0090]) (emphasis added).

Further, Ballantine teaches that "the method may include selectively electrically connecting fuel cells in a low efficiency mode (e.g., *some cells in parallel rather than in series*) in response to a control signal (e.g., a heat demand signal as from a thermostat) *to provide additional heat* into a fuel cell stack coolant fluid." (Ballantine, para. [0095]) (emphasis added). Similar language is contained in paragraph [0097] of Ballantine as well.

Finally, Ballantine teaches that "a group of *fuel cells* generally *produce a greater amount of waste heat when they are connected in parallel rather than in series*. One

reason is that the cells generally operate at a lower efficiency in such a configuration, so that more waste heat is generated.” (Ballantine, para. [0130]) (emphasis added).

The Present Application

Various independent claims of the present application are directed to a controller or other means that are configured to increase heat production by increasing fuel consumption by switching to a more serial configuration, and decrease heat production by decreasing fuel consumption by switching to a more parallel configuration. This, as is readily observed, is the exact opposite of what the Ballantine reference teaches.

Comparative test data included in Applicant’s originally filed application as well as herein demonstrate that fuel cells electrically coupled in parallel decrease the amount of heat produced by a multiple fuel cell system, whereas fuel cells electrically coupled in series increase the amount of heat produced by a multiple fuel cell system.

Figs. 1 and 2 below depict two fuel cells electrically coupled in parallel and serial configuration, respectively.

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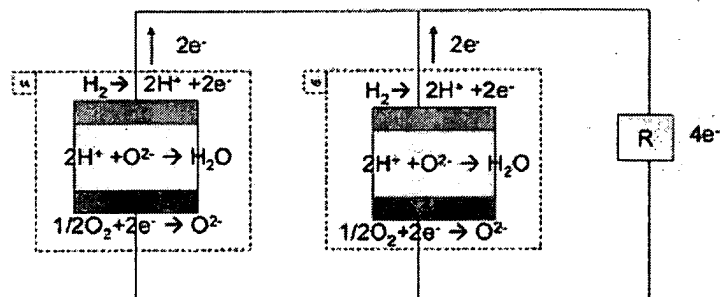


Figure 1. Parallel Configuration

overall chemical reaction of both cells together:
 $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$
 2 mol of fuel consumed by system

System Conditions:

$$V_1 = V_{1A} = V_{1B}$$

$$I_1 = I_{1A} + I_{1B}$$

4 mol e- generated, 4 mol e- are doing work on load R

First, with regard to Fig. 1, depicting two cells connected in parallel, it can readily be demonstrated that cells labeled 1A and 1B are connected in parallel in relation to each other. The partial reactions at the anode and cathode are shown. In this configuration, it is demonstrated that the reactions produce 2 mol e⁻ from each cell representing the current provided to the external load. One mole of hydrogen is consumed at each cell for a total of 2 mol indicated in the overall reaction. 2 mol protons, H⁺, are generated and react with oxygen to produce 1 mol of water at each cell. Two moles of fuel are consumed by the system. It is also important to notice that for a fixed power condition at the external load (constant current and voltage) that half of the current is supplied by each cell and the voltage drop across the load is equal to the voltage produced at each cell, which are also equal to each other by definition of a parallel circuit.

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overall chemical reaction of both cells together:
 $4\text{H}_2 + 2\text{O}_2 \rightarrow 4\text{H}_2\text{O}$

4 mol fuel consumed by system

More waste heat generated compared to parallel configuration

System Conditions:

$$V_i = V_{2A} + V_{2B}$$

$$I_i = I_{1A} = I_{1B}$$

8 mol e⁻ generated, 4 mol e⁻ are doing work on load R

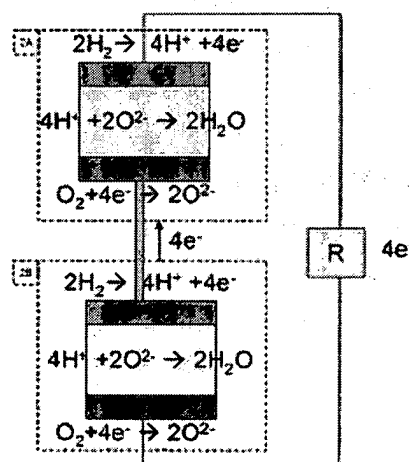


Figure 2. Series Configuration

With regard to Fig. 2, depicting two cells connected in series, for the same 4 mol e⁻ supplied to the external load, each cell needs to produce 4 mol e⁻ for a total of 8 mol e⁻.

The 4 mol e⁻ generated by cell 2B are consumed by cell 2A rather than doing work on the external circuit. In this configuration, the fuel cells are running at a high current, low voltage regime. This series configuration consumes twice as much of the reactants and produces more waste heat for the same power (constant current and voltage) delivered to the external load.

In consideration of the figures filed with the present application, originally filed Figure 5A shows the current output capability for a series and a parallel configuration. At point 515, the current, voltage, and, thus, power output from the system (two cells either in series or parallel) is fixed. At this point (515) a switch from series to parallel configuration would be completely transparent to an external circuit. The difference is then only how much fuel is consumed and how much waste heat is generated in a given configuration. Thus, in relation to the arguments above, **a series configuration of two cells would require twice as much reactants and produce more waste heat as the parallel configuration.** The series configuration is the lesser efficient state.

Further, Applicants submit such comparative test data to show that the Ballantine reference is inoperable as described and/or claimed. Specifically, Ballantine makes statements about parallel and serial configuration that contradict what the present application has presented. Specifically, Ballantine states the following:

Without wishing to be bound by theory, a group of fuel cells generally produce a greater amount of waste heat when that are connected in parallel rather than in series. One reason is that the cells generally operate at a lower efficiency in such a configuration, so that more waste heat is generated. (Ballantine, para. [0130]).

Ballantine does not provide a physical explanation to support the above statement, but merely states that this is known in the art as follows:

There are various fuel cell operating regimes that result in relatively low efficiency operation and the production of relatively high amounts of waste heat. Prior art systems are generally configured to avoid such regimes as a means of maximizing system efficiency. However, in systems balancing both heat demand and power demand signals, it may be desirable to switch between such modes. Other examples of low efficiency operating modes include reactant starvation, operation at temperatures outside the normal operating range of fuel cell, and producing a given amount of power at low voltage and high current (e.g., cell voltages less than 0.4 volts).

(Ballantine, para. [0018]).

Therefore, in light of Applicant's findings, the low voltage, high current, low efficiency mode described by Ballantine would correspond to a serial configuration and not a parallel configuration of fuel cells that Ballantine describes.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Respectfully submitted,

1/30/2009
DATE


Kurt Ulmer

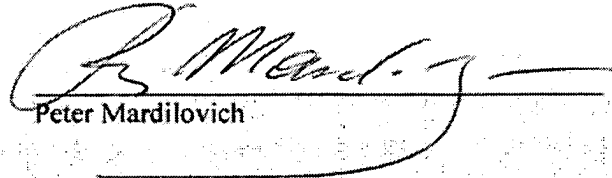
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David Champion

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Gregory Hermon

01/30/09
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Peter Mardilovich